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# Panel-like structural element, especially roofing board

Most of the constructional materials used nowadays, such as wall tiles, concrete, timber and timber materials, asbestos cement, and so on, exhibit a more or less pronounced permeability to water vapor. Only the permeability of metals and specific plastics and also glass is already extremely low at relatively low layer thicknesses.

This water vapor permeability is characterized by the water vapor diffusion resistance factor μ, as it is known, which specifies the amount by which the diffusion resistance of the layer of a specific constructional material is greater than that of a quiescent air layer of the same thickness.

For the purposes of comparison, a few approximate values are listed:

| | |
|---|---|
| Air | 1 |
| Soft fiberboard | 5 |
| Gas concrete | 5 |
| Wall tiles | 10 |
| Chipboard | 15 |
| Roof tiles | 40 |
| Timber | 100 |
| Bitumenized roofing paper | 3,000 |
| Soft PVC | 20,000 |
| Various plastics, namely synthetic condensation and polymerization products | 100,000-500,000 |
| Aluminum | 750,000 |

The critical factor for effective water vapor permeability is the product of the resistance factor μ and layer thickness s; therefore a relatively permeable material such as roofing paper (μ = 3000) can still

quite possibly be used as a vapor barrier or sealing film because of its high layer thickness. In addition to the diffusion resistance factor, the water vapor forward resistance $\frac{1}{D}$ (h) or the water vapor forward index D(1/h) or $k_D$ ($g/m^2$htorr) or simply, in accordance with DIN 53 379 (draft May 1957) or DIN 53 122, the water vapor permeability D' ($g/m^2$day) at 20°C and a gradient of the relative atmospheric humidity of 85 to 0% is specified.

These various types of statement for the permeability are related as follows:

$$\text{at } 20°\text{C } \frac{1}{D} = 1.6 \cdot 10^5 \cdot \mu \cdot s \text{ (h)}$$

$$D = 7.5 \cdot 10^{-5} \cdot k_D$$

$$358 \cdot k_D = D' \text{ (g/m}^2\text{day; 85/0\%)}$$

If such a water vapor permeable constructional material is then used as a dividing wall between two systems with different air temperatures and different relative atmospheric humidities, such as the outer wall of a dwelling house with wintry outside temperatures and air-conditioned interior, then on the basis of the prevailing vapor pressure gradient $p_i - p_a$ ($kg/m^2$) and the diffusion resistance $\frac{1}{D}$(h), water vapor diffusion from the inside to the outside necessarily occurs, with the following diffusion flow density:

$$g = \frac{p_i - p_a}{\frac{1}{D}} \text{ (kg/m}^2\text{h)}$$

In this case, it is a function only of the respective thermal forward resistance whether the quantity of water vapor diffusing may possibly condense on the inside surface (as dew) or only within the wall element, namely in that layer where the effective vapor pressure reaches the saturation vapor pressure.

The computational determination of the quantity of the water vapor diffusing gives the following result, under entirely conventional boundary conditions, for example 20°C, 80% rH inside; -10°C, 85% rH outside, but such a wall element would be wetted through completely in a few days.

Wetting through in turn reduces the thermal insulation, as a result of which the conditions become even less favorable, and the structure of the constructional material is damaged as a result of ice formation, swelling, rotting and so on.

These wetting-through phenomena are entirely known from practical experience, and the explanations above are confirmed directly by experiment (cf. H. Schäcke, W. Schüle, FBW-Bericht 18, Stuttgart (1951)).

The necessary measures for preventing wetting-through may be determined by a graphical method proposed by H. Glaser, Kältetechnik [refrigeration], Volume 10 (1959).

In particular, for this purpose the arrangement of a vapor brake on the room side has been proposed for those wall or roof elements which are normally exposed, on the inside and outside, to extremely different air temperatures and air humidities. The vapor brake used is, for example, films made of polyethylene, polyisobutylene and thin aluminum foils.

In particular in single-shell roof constructions, a warm roof as it is known, use is made of roofing papers based on bitumen with the conventional wool felt or the newer glass nonwoven inlay and, possibly, with additional metal foil inlays. These vapor brakes are arranged between the loadbearing roof covering and additional thermal insulation, and they can possibly also be adhesively bonded to the surface on the room side, like a wallcovering.

Roofing boards based on straw are being offered which, in order to avoid these disadvantages, are laminated on all sides with paper, to be specific with Kraft paper on the room side and with bitumenized paper on the roof side. This construction is also capable of being used only under certain conditions, since the outer side is more vapor-proof than the inner side and therefore wetting through can likewise not be prevented.

It has also already been proposed to provide these load bearing and thermally insulating roofing boards on the underside with an extremely vapor-tight aluminum foil. However, this proposal has another, unforeseeable disadvantage, which has an effect in particular in the case of statically stressed roofing boards.

This is because if a wall element or a roofing board which separates two systems that are very different in relation to the atmospheric temperature and humidity is protected by a very vapor-tight barrier film on the side exposed to the higher vapor pressure, then the result is increasing drying out of the component, as was also demonstrated in practice in the experiment previously mentioned (H. Schäcke, W. Schüle, FBW-Bericht 18, 1951).

As our own investigations showed, extensive drying out of, for example, a board-type material based on vegetative raw materials, bonded with synthetic binders results in severe embrittlement and a serious decrease in the bending strength, which is important for the static stressing, of the order of magnitude of 20-50% (depending on the density).

On the basis of these considerations, the result was the development of a panel-like structural element suitable as a wall element or roofing board which, according to fig. 1 comprises a thermally insulating load bearing board (1) and, according to the invention,

on the room side is provided with a layer (2) of defined water vapor permeability and on the outside with a water-repellent and briefly water-impermeable but exceptionally water vapor permeable layer (3).

The water vapor permeability of the diffusion-hindering layer arranged on the room side is in this case defined to be at least 0.5 and at most 5 $g/m^2$day (at 20°C and a gradient in the relative atmospheric humidity of 85:0%), preferably 1 $g/m^2$day. The permeability should not be greater than 5 $g/m^2$day, in order to prevent wetting through of the board with certainty, but should not be less than 0.5 $g/m^2$day either, in order that extensive drying out does not occur.

Depending on the type of joint formation at the butt joints between the boards, the optimum value of the water vapor permeability will lie closer to one or the other limiting value.

Plastic films of specific thickness are primarily considered for the diffusion-hindering layer, particularly good results have been obtained with plastic-coated paper films, in which, by means of the paper side, a good bond with the load bearing board can be brought about relatively easily.

The solution which was best in technical and economic terms resulted from the use of a paper with a covering of 10-100 $g/m^2$ polyvinylidene chloride. Other synthetic polymerization and condensation products are also considered, but from process engineering reasons, it is important that the softening point of the plastic used does not lie below 100°C.

Arranging a water-tight and vapor-tight film on the room side results in the panel-like structural element being particularly sensitive to the action of water

which, during installation, from time to time cannot be avoided entirely.

For this reason, the outside of the element is also coated, specifically, according to the invention, with a layer (3) which is as impermeable as possible to liquid water but completely permeable to water vapor. Particularly good results have been obtained from the application of a heat-curable condensation product, for example of the same binder or a similar binder to that used for the load bearing board. In the case of curing within a heated press, a closed film is formed on the outside of the structural element and, during the condensation, tears under its own vapor pressure only in the region of the surface pores, and therefore produces the openings (4) required for the subsequent vapor diffusion.

It is also possible to use thin plastic films, but their water vapor permeability should be as high as possible. In each case, adequate adhesion to the roof skin, which is normally bonded on with hot bitumen, must be ensured.

In the case of multi-layer wall elements according to fig. 2, the diffusion-hindering layer (2) can also be arranged in a layer joint, if possible in the layer joint (2) closest to the room side (1). In this case, use is made of a paper film with a plastic inlay.

Claims

1. A panel-like structural element for closing off a room horizontally or vertically, formed by a single-layer or multi-layer board material based on vegetative raw materials such as wood chips, flax or hemp shavings, bagasse, jute or cotton stems, cereal straw and the like and also mineral or synthetic organic foamed materials or a mixture of the aforementioned raw materials, bonded with characteristic or specially added mineral or organic binders, wherein a plastic film with a defined water vapor permeability is arranged on the room side as a vapor brake.

2. The panel-like structural element with vapor brake as claimed in claim 1, wherein the water vapor permeability of the vapor brake at 20°C and with a gradient of the relative atmospheric humidity from 85:0% is between 0.5 and 5, preferably about 1 $g/m^2day$.

3. The panel-like structural element with vapor brake as claimed in claims 1-2, wherein the vapor brake comprises a plastic-coated paper.

4. The panel-like structural element with vapor brake as claimed in claims 1-3, wherein the vapor-braking layer consists of a thermoplastic whose softening point is above 100°C.

5. The panel-like structural element with vapor brake as claimed in claims 1-4, wherein the vapor-braking layer consists of polyvinylidene chloride.

6. The panel-like, multi-layer structural element with vapor brake as claimed in claims 1-5, wherein a plastic film coated with paper on both sides or

a paper film with plastic inlay as vapor brake is arranged in the layer joint as close as possible to the room side.

7. The panel-like structural element with vapor brake as claimed in claims 1-6, wherein the outer side, which faces the ventilation layer and the actual outer skin, has a plastic layer which can be wetted moderately by liquid water and is relatively impermeable to it, but is permeable to water vapor.

8. The panel-like structural element as claimed in claims 1-7, wherein the outside surface is finished with the same or similar synthetic resin as is also used as a binder for the board-like material, preferably condensation products of aldehydes with compounds containing amino groups, such as melamine, urea or with phenols or mixtures of the three last-named compounds.